QUALITY ASSURANCE PROJECT PLAN
HYDROGEOLOGIC INVESTIGATIONS

DRAFT

for

Stichting

MAYFLOWER TAILING PONDS
Wasatch County, Utah

Approvals

Principal-in-Charge________________________Date____________
QA Officers________________________________Date____________
Utah Department of Health_______________Date____________
USBR______________________________________Date__________

Prepared By

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1.0 PROJECT DESCRIPTION

This plan presents the Quality Assurance Program for conducting hydrogeologic studies at the Mayflower Tailing Site in Wasatch County, Utah. This Quality Assurance Project Plan (QAPP) will guide the fieldwork, sampling and analytical activities. The hydrogeologic field investigation will consist of approximately 16 borings which will be drilled and sampled and then completed as monitor wells to identify and characterize the subsurface soil, bedrock and groundwater conditions. Several of the borings will be drilled in and adjacent to the tailing impoundments to determine geotechnical and geochemical properties for the tailing and natural soils. It is estimated that a minimum of three borings will be drilled downgradient of the tailing impoundments with several additional borings located upgradient of the ponds. All borings will be completed as piezometers/monitor wells so that water quality sampling and water level measurements may be performed.

The Mayflower Tailing are contained within three unlined impoundments covering approximately 5 acres. There are approximately 400,000 tons of tailing within the impoundments. The material was placed by Hecla Mining during the operational period of the Mayflower Mine (between 1962 and 1972). The material deposited was discharged onto the ponds using several different methods over the 10 year depositional period. However, the majority of the tailing were deposited from one or two upstream points. The impoundments were built in succession as needed with each pond constructed using basically the same methods. However, some additional design modifications were made for each containment dike based on the performance of the others. The tailing were deposited at approximately 30% solids by volume.

Bingham Engineering placed 4 exploratory borings within the two upper impoundments (Ponds 1 and 3) in 1983 to evaluate the overall geotechnical characteristics of the material and their suitability for use as fill.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

Bingham Engineering will be responsible for the field exploration, water sampling and a portion of the laboratory testing. This will include the logging of each boring, obtaining samples for subsequent laboratory testing and supervising the installation of the monitor wells. In addition, Bingham Engineering will be responsible for coordinating the laboratory testing which will be subcontracted to outside labs.

2.1 Organization

The responsibility for the project will be broken down as presented below:

Clark M. Mower (Bingham Engineering)
Principal-In-Charge (PIC)

Galen Williams (Bingham Eng.)
Stan Plaisier
Project Managers (PM)

Staff

Brad Derrick (Bingham Eng.)
Project Quality Assurance Officer (PQAO)

2.2 Project Responsibilities

The PIC will have controlling responsibility of the project and will direct operations and be responsible for all contracts and ultimate quality control. He will report to Stichtings and provide information to Delft.

The PM will oversee all operations and assure that the project is being conducted in accordance with the QA. He will also direct the field operations. He will also be responsible for providing coordination with the governmental agencies.

The PQAO will be responsible for assuring the compliance with the QA and will:

1 Review all collected data
2 Monitor all procedures and identify problems
3 Recommend corrective actions
4 Inform the PIC of all activities
5 Prepare written reports at the frequency outlined in Section 12.0 to address compliance with the approved QA plan. This will include review of the accuracy of all monitoring and sampling results and chain of custody procedures. This report will include a history of any problems and the corrective measures taken to remedy those problems.

3.0 QUALITY ASSURANCE OBJECTIVES

The overall objective of the quality assurance program is to develop and implement procedures for field sampling, chain of custody, laboratory analysis and reporting that will provide legally defensible results in a court of law. Specific procedures to be used for sampling, chain of custody, calibration, audits, preventive maintenance and corrective actions are described in other sections of this QAPP.

4.0 HYDROGEOLOGIC/GEOCHEMICAL STUDIES

4.1 HYDROGEOLOGY

The Mayflower tailing site is located on a south facing moderate slope. The site is underlain by 100 to 260 feet of alluvial and colluvial deposits consisting of clayey gravels or sandy gravels with cobbles and boulders. There are several zones of thick low permeability clayey gravels.

Based on USBR and Bingham Engineering drill holes, groundwater was measured both at the original ground surface below the tailing pond and from 100 to 200 feet below the ground surface at some distance from the impoundments. The shallow groundwater levels may be due to a perched condition (groundwater mound) beneath the impoundments. The hydrogeologic study will assess whether heavy metals are leaching out of the impoundments into the soil and groundwater table. In addition, samples of tailing will be obtained to characterize the chemical composition of the tailing deposits.

4.2 MONITOR WELL INSTALLATION

In order to assess the potential contamination of the soil and groundwater it will be necessary to construct piezometers/monitor wells. The piezometers will be constructed to determine the groundwater depths and the direction of movement of water beneath the site. In addition, soil and groundwater samples will be obtained to assess if the subsurface materials have been contaminated. As shown on Figure 2 of the Work Plan, a total of up to 16 piezometers will be constructed as part of the hydrogeologic investigation. Delft Soil Mechanics Laboratory (Delft) has prepared guidelines for the hydrogeologic investigation and these have been summarized in Reference 1. Basically the request is that the downgradient borings be drilled first, followed by the upgradient holes, then the borings to the side of the impoundments and finally the borings through the tailing impoundments. Several piezometers will be established at different depths in the same general location, however, none of the piezometers will be clustered in the same hole.

All piezometers, except the TD (tailing) borings, the DD (deep) boring and the MD (medium) boring will be completed in the uppermost aquifer. The DD borings will extend to bedrock with the piezometer established in the bottom of the colluvial materials. The TD piezometers will be established in the tailing impoundments. Drill holes for piezometers will be drilled using techniques and equipment which minimizes the contamination and alteration of the soil and groundwater. It is recommended that hollow-stem augers, air-rotary, air-hammer or cable-tool techniques be used to satisfy the requirement for a relatively clean, stable hole. Mud-rotary techniques will not be allowed.

Utmost care shall be taken to prevent downward movement of potentially contaminated water or tailing from falling down the drill hole or moving down the annulus of the cased piezometer. Measures which may be employed include keeping a positive head of water in the boring, casing the tailing zone off, not removing augers until the bentonite seal is placed, and washing tailing from downhole equipment.

The locations of the wells will be established with stakes and flagging. The drill holes will be constructed to the proposed minimum diameters shown in Table 4-1. Care should be taken to make the hole as straight and plumb as possible. The hole must be clean and stable to allow completion of the well to the prescribed depths. This may require the use of temporary steel casing during the drilling. If temporary steel casing is used during drilling, the temporary casing shall be removed in a manner so as to prevent breakage of the PVC casing and screen.

Piezometer borings will be logged by an experienced engineer/geologist based upon examination of soil samples and drilling characteristics. Continuous relatively undisturbed soil samples will be obtained at certain depths within the drill holes. These depths will generally be in the tailing, in the upper 10 to 20 feet of the native soils, within any perched water zones and in a zone 10 feet above to 10 feet below the upper aquifer surface. Split spoon soil samples will be obtained at 5-foot intervals or at changes in soil type when undisturbed samples are not required. Vertical permeability shall be measured on undisturbed soil samples in the laboratory for the most permeable and least permeable range of materials encountered as determined visually.

Table 4-1 summarizes the proposed monitor wells including the estimated depths and length of screen. Actual completion depths of the piezometers will be determined by site conditions encountered during drilling. Screen will be set insofar as practicable in the same units and at the same depths in the uppermost aquifer. Total footage is estimated to be 1890 feet.

The piezometers will be constructed as shown on Figure 4-1, Typical Monitor Well Construction Details. The casing shall be constructed using new 4-inch diameter NSF (National Sanitation Foundation) approved PVC Schedule 40 plastic pipe. All couplings, except the end caps, shall be joined to the pipe and screen using mechanical screw joints. Casing joints shall have O-ring seals rated for differential pressures through the joint in excess of 50 psi with no leakage. The use of solvents, glues and/or other adhesives will not be allowed. The screen shall be commercially fabricated, machine-slotted PVC Schedule 40 plastic pipe. The screens shall have a 10 slot (0.010 openings) with a minimum of 2.5 square inches of intake per lineal foot of screen.

Each piezometer shall be sand-packed with a clean, washed, quartzose sand (Fountain #16-30 or equivalent). The sand pack and grout shall be installed through a temporary PVC tremie pipe. The sand pack shall extend a minimum of 5 feet above the top of the screen. A minimum of one foot of bentonite will then be placed over the sand pack to seal the piezometer. Each hole will then be sealed to the surface with a grout consisting of a mixture of Portland Cement, four pounds of bentonite per bag of cement, with not more than eight gallons of water per bag of cement. All monitor wells shall be protected by a steel protective casing with locking cap which is embedded in a concrete pad. The protective covers shall be painted with a high quality oil-based paint. A durable case-hardened steel lock will be provided and all locks shall be keyed the same. Figure 4-1 gives the typical piezometer/monitor well construction.

Each well shall a location marker post installed adjacent to it. The posts shall consist of a 2-inch diameter steel pipe approximately 8 feet long. The posts shall be embedded in concrete with 5 feet sticking up above the ground surface.

Although field conditions will determine actual completions, it is expected that most piezometers in the upper aquifer will be about 120 feet in depth. However, if a perched level is encountered above the upper aquifer, the piezometers may be installed at significantly shallower depths. The deepest piezometer at the site is estimated to be about 270 feet in depth.

4.3 FIELD MEASUREMENTS

Water level Measurements

Ground water level measurements shall be made and recorded to 0.01 foot using chalked tape techniques, an electric well probe or an electronic transducer. The time of measurement and any observations of pertinent conditions or activities shall be recorded. Measurement of water levels in piezometers shall be performed before any pumping or sampling. Each measurement will be duplicated as a check to ensure accuracy.

Water levels will be measured at least once a month during the duration of the project with the data entered on a form such as Table 4-4.

Conductivity and pH Measurements

Prior to making pH or conductivity measurements, each piezometer will be prepumped. At least two casing volumes will be removed prior to these measurements. Measurements will be made in a small container or in a flow cell fed from the discharge line of a peristaltic pump. Measurements of pH, specific conductance and temperature are to be made immediately upon collection of the sample and at field temperature.

Conductivity and pH measurements are to be performed in accordance with EPA (Reference 2) methods 120.1 and 150.1, respectively.

The meters used to measure pH and conductivity and procedures used for calibration and measurements are outlined in Section 6.0.

4.4 SLUG TESTS

Slug tests will be performed on all piezometers installed as part of the hydrogeologic investigation to evaluate the condition of the piezometers and the formation constants. Slug tests will be conducted and evaluated in accordance with the methods of Hvorslev (Hvorslev, 1951,and Cedergren, 1967); Copper, Bredehoeft, and Papadopoulos (Lohman, 1979); and (Ferris and Knowles (1962). Type curve graphical techniques such as those described in Walton (1970) will be used for evaluation.

4.5 SURVEY AND SURVEY CONTROL

All completed monitor wells will be surveyed to second order standards using levels and electronic distance measuring (EDM) equipment. The surveying activities will be under the direction of a registered land surveyor. All control will be referenced to the existing USBR datum at the Mayflower Site.

4.6 LABORATORY ANALYTICAL TESTING

All laboratory chemical analyses will be conducted in accordance with EPA standards and procedures. Analytical parameters, their detection limits, method of analysis and hold times are given on Table 4-2 for the characterization samples and on Table 4-3 for the groundwater quality samples. Specific conductance and pH will be measured both in the field and in the laboratory.

The laboratory(s) will be responsible for their internal quality control, which will include method blanks and spikes as required by EPA/UDH certified laboratories.

TABLE 4.1

MAYFLOWER TAILINGS STUDY
HYDROGEOLOGIC INVESTIGATION
DRILL HOLE DETAILS

HOLE NO.	MIN. BORING DIA (IN)	PIEZO DIA (IN)	EST. BORING DEPTH (FT)	SCREEN LENGTH (FT)	BORING LOCATION (TO TAILINGS)	EST WATER LEVEL (FT)	EST BEDROCK DEPTH (FT)
SD-1	8.0	4	120	10	DOWNSTREAM	100	240
MD-1	8.0	4	180	10	DOWNSTREAM		
DD-1	8.0	4	250	10	DOWNSTREAM		
SD-2	8.0	4	195	10	EAST	175	260
SD-3	8.0	4	170	10	DOWNSTREAM EAST	150	250
SD-4	8.0	4	120	10	DOWNSTREAM	100	220
SD-5	8.0	4	120	10	DOWNSTREAM SOUTH	100	180
SD-6	8.0	4	220	10	UPSTREAM	200	260
SD-7	8.0	4	145	10	UPSTREAM	125	230
DD-7	8.0	4	240	10	CENTER		
TD-8	8.0	4	12	5	POND 3	16	230
SD-8	8.0	4	30	10	POND 3	17	
TD-9	8.0	4	15	5	POND 1	17	230
SD-9	8.0	4	33	10	POND 1	20	
TD-10	8.0	4	12	5	POND 2	15	230
SD-10	8.0	4	28	10	POND 2	18	

TOTAL FOOTAGE 1890

TABLE 4-2
TAILINGS AND SOIL SAMPLES

**** TO BE PROVIDED BY DELFT ****

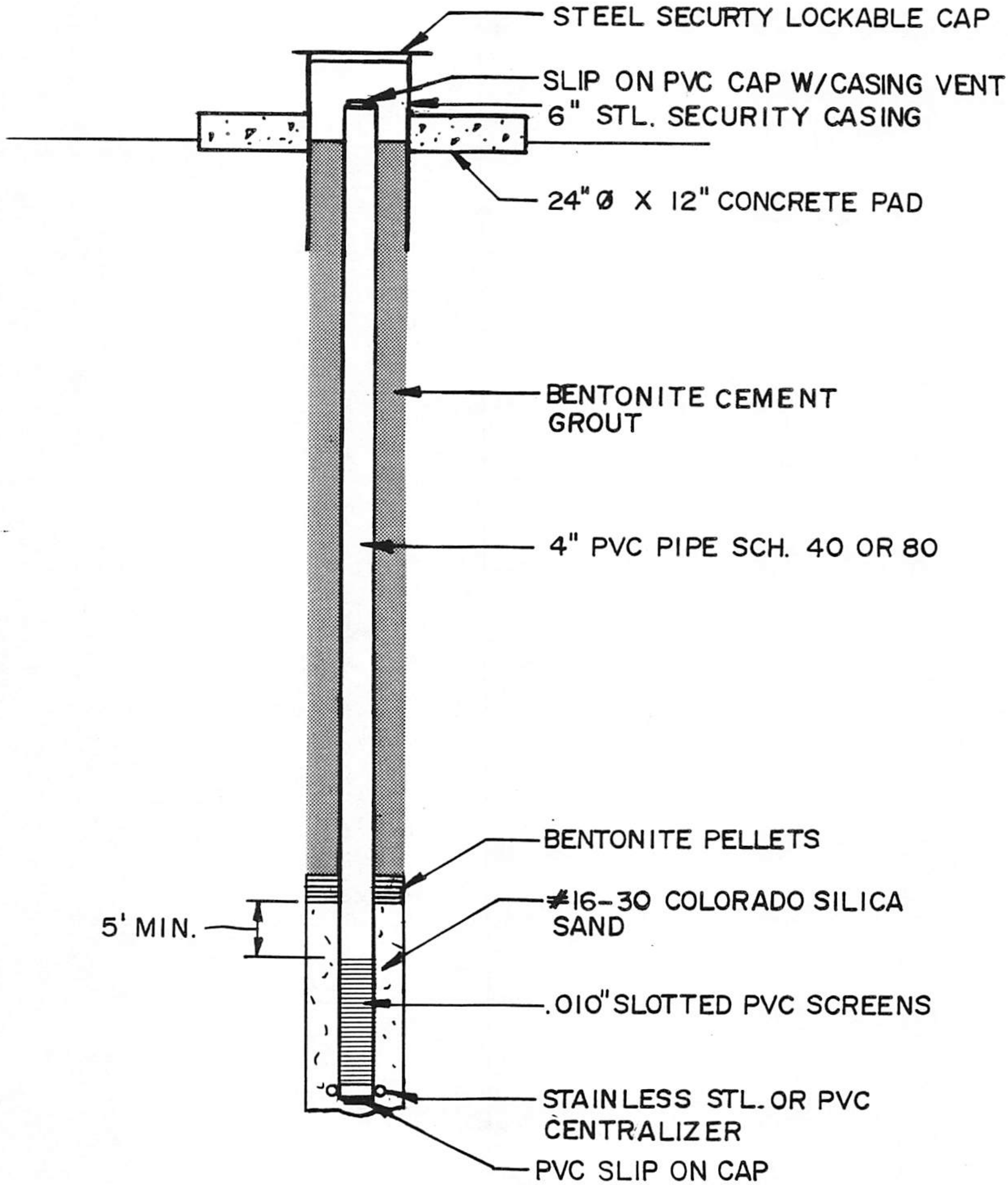
TABLE 4-3
GROUNDWATER QUALITY TESTING

**** TO BE PROVIDED BY DELFT ****

TABLE 4-4
PIEZOMETRIC LEVEL SUMMARY SHEET

PROJECT NAME ______________________ PROJECT NO. ______________

DATE	PIEZOMETER NUMBER AND SURFACE ELEVATION												



TYPICAL PIEZOMETER/MONITOR WELL CONSTRUCTION DETAILS

NOT TO SCALE

FIGURE 4.1

5.0 SAMPLING PROCEDURES

5.1 SAMPLE SITES

The groundwater monitoring well locations are as proposed on Figure 2 of the Work Plan. They will include all the monitor wells tabulated on Table 4-1.

5.2 SAMPLE COLLECTION

Prior to sampling, the wells will be purged with a bailer, hand-operated diaphragm pump or a submersible pump. A minimum of two casing volumes will be purged before the sample collection is performed.

The sample should be collected utilizing a peristaltic pumping system in accordance with groundwater sampling Method III-10 of Reference 3.

For each sample bottle, the form given in Table 8-1 should be filled out completely and attached to the bottles. Each sample for laboratory analysis will be placed in a series of ** containers as summarized on Table 8-2. Sample containers will have preservatives added in advance. Each bottle should be filled to the top without overflowing. The bottles will not be rinsed at the site.

Sample containers should be placed out of direct sunlight, preserved, shipped and analyzed within the maximum allowable hold times as specified on Table 4-3. The preservation methods indicated conform to the requirements of Reference 4. Samples should be shipped to the laboratory as soon as possible, preferably the same day as collection. These methods call for the use of various specific type containers, addition of preserving agents, refrigeration (certain sample bottles should be immediately placed and shipped on ice), and be analyzed by the laboratory within the maximum hold times.

Blank and duplicate samples will also be taken in the field as outlined in Section 9.0. Sample labels, field sampling and analysis records, and chain-of-custody records will be prepared as outlined in Section 8.0.

During the sampling, pH, temperature and specific conductance measurements will be performed at each site and recorded on the form shown on Table 8-2. Measurements will be made in small sample containers or in a flow cell connected to the peristaltic pump. The meters used to measure pH and conductivity and procedures used for calibration are outlined in Section 7.0.

6.0 ANALYTICAL PROCEDURES

EPA-approved analytical methods will be used for this project. These procedures are listed on Tables 4-2 and 4-3. Specific conductance and pH will be measured in the field. Checks for pH and specific conductance will be run in the lab. Acceptance criteria for routine laboratory QC checks will be within plus or minus two standard deviations of the precision and accuracy data as specified in the appropriate EPA methodology (Reference 5) and established by the certified laboratory.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

7.1 General

Meters used to measure pH and specific conductance will be calibrated, as outlined below prior to and during use. Source and identification (lot number, etc.) of standards used to calibrate will be recorded; identification numbers of instruments used will also be recorded.

7.2 Field pH

Field pH is to be performed with one of the following:

Manufacturer	Model No.	Serial No.
VWR	49	

These meters have automatic or manual temperature correction.

Follow manufacturer's instructions for operation and standardization of instruments. Perform two-buffer standardization with buffers approximately 3 pH units apart and spanning the anticipated measurement values prior to first use and before each measurement where occasional pH measurements are made. Where frequent measurements are made, less frequent standardization (every 1 or 2 hours) is satisfactory. However, if sample pH values vary widely, standardize more frequently with a buffer having a pH within 1 or 2 units of that sample.

Standardization and measurements procedures should be in accordance with those contained in Reference 3 and Reference 14.

Notes:

1. If oil gets on the electrodes, clean the electrodes with acetone or hydrochloric acid (1+9), as necessary.
2. Store pH electrode in pH 7 buffer.

7.3 Field Specific Conductance

Field specific conductance measurements are to be performed with one of the following:

Manufacturer	Model No.	Serial No.
YSI	33	

These meters automatically indicate specific conductance corrected to 25 degrees C. Wet standardization methods (KCI standard solution) as per manufacturer's instructions, are to be used. Calibration is to be done before each sample measurement.

Temperature

Temperature should be measured using a good grade mercury-filled or dial type thermometer checked periodically against a precision thermometer certified by the National Bureau of Standards. Temperature should be reported to the nearest 1 degree C.

Water Level Meters

Water Level meters will be calibrated at least weekly. If there is evidence of malfunctioning, the meters should be calibrated immediately. Calibration checks are to be recorded in the appropriate form.

8.0 SAMPLE CUSTODY

8.1 FIELD OPERATIONS

An essential part of the sample collection activity is the documentation of the site measurements and ensuring of the integrity of the sample from collection and data reporting. This includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. The documentation of the history of the sample is referred to as chain-of-custody. The following records and actions will be taken.

1. Sample Labels Sample labels are necessary to prevent misidentification of samples. The sample label shown on Table 8-1 should be completely filled out and attached to the sample at the time of collection.

2. Field Sampling and Analysis Record Pertinent field moisture measurements and observations should be recorded. To facilitate these records the form shown on Table 8-2 should be filled out for each sample. Documentation of the sources of buffers =, standards, reagents, sample containers, etc., will be recorded on the reverse side of the form shown on Table 8-2.

3. Chain-of-Custody Record To establish the documentation necessary to trace sample possession from the time of collection, the chain-of-custody record as shown on Table 8-3 should be filled out in duplicate with one copy to accompany every sample shipment from the time of collection through receipt by the analytical laboratory. One copy of the form should be retained by the field sampler. A record of the relinquishing of the sample should be obtained as provided on Table 8-3. The sample should be delivered to the laboratory for analysis as soon as possible, usually within one day after sampling. Maximum hold times are shown on Table 4-3. The copy of the form sent to the laboratory with the samples should be returned to Bingham Engineering with analytical results

8.2 LABORATORY RESULTS

The analytical laboratory will acknowledge receipt of the samples by signing and dating the appropriate box on the form shown on Table 8-3. This form should be returned to Bingham Engineering with analytical results.

The laboratory will be State of Utah certified. The laboratory will maintain internal chain-of-custody control in accordance with its own standard quality assurance program.

TABLE 8-1

SAMPLE LABEL

Site No.____________________ Sample Location No._____________

Sample No.____

Date________________________ Time___________________________

Collector Name____

Comment____

Owner_____________________________________ Job No._____________

TABLE 8-2

FIELD SAMPLING AND ANALYSIS RECORD

Owner: ____________________________ Job No. ________________

Site No.: ______________ Sample Location No. ________ Date: _____ Time: _____

Field pH measurements: 1. ________ 2. ________ 3. ________ 4. ________

pH meter used: ____

Field specific conductance measurements: 1. _____ 2. _____ 3. _____ 4. _____

Conductivity meter used: ________________________________

Water sample temperature: ____________

Visual description of sample (color, turbidity, etc.): ________________

____

Weather: ____

Comment: ____

Collector name: ____________________

SAMPLE PRESERVATION AND ANALYSIS

TO BE PROVIDED BY DELFT SOIL MECHANICS LABORATORY

TABLE 8-3

GROUNDWATER SAMPLING AND CHAIN-OF-CUSTODY FORM

Owner:____________________________ Sampling Firm:____________________________
Address:__________________________ Address:__________________________________
__________________________________ ____
Attn: ____________________________ Attn: _____________________________________

==

Field Measurements

Well No.________________________ Sampling Equipment______________________
Sampling Date:__________________ ____
Time____________________________ Casing Volumes Removed__________________
Depth to Water__________________ Temperature_____________________________
TOC Elevation___________________ pH______________________________________
Groundwater Elevation___________ Conductance_____________________________
Weather Conditions____
Comments____
____

==

Sample Preservation and Analyses

Bottle No.	Container	Preservative	Parameters for Analyses
__________	________	____________	_______________________
__________	________	____________	_______________________
__________	________	____________	_______________________

Receiving Laboratory:____
Address:____
____
Attn: ____

Date Received:____________________ Time:__________________
Note any damaged or missing samples_________________________
____
Accepted by____

==

Chain-of-Custody

Relinquished by: (Signiture)	Date	Time	Received by: (Signiture)	Date	Time
Relinquished by: (Signiture)	Date	Time	Received by: (Signiture)	Date	Time

9.0 INTERNAL QUALITY CONTROL CHECKS

9.1 FIELD OPERATIONS

During each sampling event two blind field duplicates will be prepared and submitted to the laboratory. State of Utah personnel may conduct spiking of samples in accordance with their own quality assurance plan. Splitting for duplications will be done by either (1) pumping waters through a "T" and simultaneously filling sample containers or (2) filling containers from a large stainless steel bucket filled with water sample.

One field blank will be collected per set of samples. The blank sample will be prepared by pumping distilled water through the peristaltic pumping system into sample containers or filling sample containers form the stainless steel bucket in the same manner as done for the typical sample.

9.2 LABORATORY OPERATIONS

The laboratory will conduct its own internal quality control checks in accordance with its own QA program as a part if State certification. This will include running at least 10 percent duplicates and spike samples. The laboratory will summarize the results of these quality control checks and submit them with the analytical results.

10.0 PERFORMANCE AND SYSTEM AUDITS

The results of all field measurements, laboratory analyses and quality control checks will be performed immediately after the completion of the specific activities.These audits will be performed by the PQAO. These reviews (audits) will be performed to (1) verify that the QAPP is being implemented, and (2) to detect and define problems so that immediate corrective actions may be implemented.

11.0 CORRECTIVE ACTION

Corrective action will be initiated if work is not conducted in accordance with the plan. This includes any sample collection deficiencies or unreliable analytical results which prevent the QA objectives for the project from being met. The criteria for acceptable sample collection data are given in Section 5.0 and the laboratory's QA program provides the criteria for acceptable analytical results.

Corrective action may be requested by any individual on the project but initiation is the responsibility of the PQAO. The PIC is responsible for approving the corrective action. Problems and quality assurance corrective actions will be annotated in the quality assurance report.

13.0 REFERENCES

1. Letter from Dr. ir. M. Loxham, Delft Soil Mechanics Laboratory, to Clark Mower. Drilling Campaign Mayflower Tailings, dated February 2, 1987

2. EPA, 1979, Methods for Chemical Analysis of Water and Wastes: EPA 600-4-79-020

3. EPA, 1983, Characterization of Hazardous Waste Sites - A Methods Manual, Volume II, Available Sampling Methods; EPA-600/4-83-040.

4. Morrison, Robert D., 1983. Ground water Monitoring Technology, Procedures, Equipment and Applications. Prairie Du Soc: Timco Manufacturing, Inc., 111 p.

12.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The PQAO will prepare a written QA report at the end of the field investigation phase as outlined in Section 3.2. The report will be distributed to the same individuals receiving this plan as listed on the Table of Contents. The report will address installation of the wells according to the plan, proper documentation of observations and measurements, completeness of data collected, listing and basis of any unacceptable data, findings of the audits, problems identified, and corrective actions taken. No specific calculations, graphs or charts are required.